two neon rays are amongst those most frequently observed, while the red ray of hydrogen and one red ray of krypton have been noticed only once. The predominance of neon is not surprising, seeing that from its relatively greater proportion in air and its low density it must tend to concentrate at higher elevations.

So large a number of probable identifications warrants the belief that we may yet be able to reproduce in our laboratories the auroral spectrum in its entirety. It is true that we have still to account for the appearance of some and the absence of other rays of the newly discovered gases, which, in the way we stimulate them, appear to be equally brilliant, and for the absence, with one doubtful exception, of all the rays of nitrogen. If we can not give the reason of this it is because we do not know the mechanism of luminescence, nor even when the particles that carry the electricity are themselves luminous, or whether they only produce stresses causing other particles which encounter them to vibrate; yet we are certain that an electric discharge in a highly rarefied mixture of gases lights one element and not another in a way which, to our ignorance, seems capricious.

The Swedish North Polar Expedition concluded from a great number of trigonometrical measurements that the average above the ground of the base of the aurora was 50 kilometers (34 miles) at Cape Thorsden, Spitzbergen;[3] at this height the pressure of the nitrogen of the atmosphere would be only about one-tenth of a millimeter, and Moissan and Deslandres have found that in atmospheric air at pressures less than one millimeter the rays of nitrogen and oxygen fade and are replaced by those of argon and by five new rays which Stassano identifies with rays of the more volatile gases measured by us. Also, Collie and Ramsay's observations on the distance to which electrical discharges of equal potential traverse different gases throw much light on the question. They find that, while for helium and neon this distance is from 250 to 300 millimeters, for argon it is 45½ millimeters, for hydrogen it is 39 millimeters, and for air and oxygen still less.

This indicates that a good deal depends on the very constitution of the gases themselves, and certainly helps us to understand why neon and argon, which exist in the atmosphere in larger proportions than helium, krypton, or xenon, should make their appearance in the spectrum of auroras almost to the exclusion of nitrogen and oxygen.

How much depends not only on the constitution and it may be temperature of the gases, but also on the character of the electric discharge, is evident from the difference between the spectra at the cathode and anode in different gases, notably in nitrogen and argon, and not less remarkably in the more volatile compounds of the atmosphere.

Without stopping to discuss that question, it is certain that changes in the character of the electric discharge produce definite changes in the spectra excited by them. It has long been known that in many spectra the rays which are inconspicuous with an uncondensed electric discharge become very pronounced when a Leyden jar is in the circuit. This used to be ascribed to a higher temperature in this condensed spark, though measurements of that temperature have not borne out the explanation. Schuster and Hemsalech have shown that these changes of spectra are in part due to the oscillatory character of the condenser discharge, which may be enhanced by self-induction, and the corresponding change of spectrum thereby made more pronounced.

If we turn to the question what is the cause of the electric discharges which are generally believed to occasion auroras, but of which little more has hitherto been known than that they are connected with sun spots and solar eruptions, recent studies of electric discharges in high vacua, with which the names of Crookes, Röntgen, Lenard, and J. J. Thomson will always be associated, have opened the way for Arrhenius to suggest a definite and rational answer. He points out that the frequent disturbances which we know to occur in the sun must cause electrical discharges in the sun's atmosphere far exceeding any that occur in that of the earth. These will be attended with an ionisation of the gases, and the negative ions will stream away through the outer atmosphere of the sun into interplanetary space, becoming, as Wilson has shown, nuclei of aggregation of condensable vapors and cosmic dust. The liquid and solid particles thus formed will be of various sizes; the larger will gravitate back to the sun, while those with diameters less than one and a half thousandths of a millimeter, but nevertheless greater than a wave length of light, will in accordance with Clerk-Maxwell's electromagnetic theory, be driven away from the sun by the incidence of the solar rays upon them, with velocities that may become enormous, until they meet other celestial bodies, or increase their dimensions by picking up more cosmic dust, or diminish them by evaporation. The earth will catch its share of such particles on the side that is turned toward the sun, and its upper atmosphere will thereby become negatively electrified until the potential of the charge reaches such a point that a discharge occurs, which will be repeated as more charged particles reach the earth.

[3] This conclusion was afterwards shown to have no logical basis. See Terrestrial Magnetism. 1898. Vol. III, pp. 152-154 and 164-169.—ED.

TORNADO AT MOUNDVILLE, ALA.

By FRANK P. CHAFFEE, Section Director, Montgomery, Ala., dated February 8, 1904.

The tornado at Moundville, Ala., on January 22, 1904, was first felt 2 miles southwest of Moundville, Hale County, Ala., at about 1:20 a. m., seventy-fifth meridian time. The previous evening was warm, with moderately heavy rains at intervals, and the wind blowing in fitful, heavy gusts from the southeast and south. The tornado was most destructive at Moundville, at which place nearly every building was demolished, several freight cars destroyed, 36 persons killed, and 80 injured out of a population of about 300.

The path of the storm extended from southwest to northeast; it was about 5 miles in length and 200 yards wide at the point of greatest destruction. It was accompanied with a funnel-shaped cloud, which had a phosphorescent glow and emitted blinding flashes of lightning, and from which was heard a loud, rumbling noise, resembling that caused by a number of rapidly-moving freight trains. The tornado lasted but a few minutes, and there seems to have been no evidence of its having any bounding motion.

A large, well-constructed railroad warehouse, 40 other frame buildings, a large water tank, and several freight cars were literally torn to pieces. It is reported that some of the timbers of the structures destroyed were twisted and splintered, and that the ground along the path of the storm was swept bare of vegetation. Bales of cotton, stored in the warehouse mentioned above, were torn open and the cotton scattered for some distance. While the destructive force of the storm did not extend over 5 miles northeast of Moundville, débris from that place is reported to have been carried as far as Tidewater, a village in Tuscaloosa County, about 19 miles to the northeast. Effort was made to ascertain the direction of the whirling motion of the storm, but reports as to this are too conflicting to be of value. The storm occurred at such an hour that few persons saw the funnel-shaped cloud or noted its movements.

At Tuscaloosa, about 15 miles north, and at Greensboro, about 24 miles south of Moundville, there were much lightning, moderately heavy rains, and high, but not destructive, winds.

At Hull, a small town about 5 miles northeast of Moundville, a large lumber mill was destroyed.

At Birmingham, about 60 miles northeast, the wind was also destructive, demolishing 35 cabins in the northern suburbs of that city, though causing no loss of life. The highest registered wind velocity at that place for 5 minutes was 50 miles per hour from southeast, with an extreme of 60 miles per hour, though the storm seems to have lost its tornado characteristics before reaching that place. The approximate value of property destroyed is as follows: Moundville, $80,000; Hull, $8000; Birmingham, $4000; total, $92,000.

The tornado at Moundville occurred on the southeast side of a decided barometric depression which swept rapidly northeastward over northern Mississippi, or northwestern Alabama, during the night of January 21–22, when the pressure was rather low, though not extremely so, at Birmingham, Meridian, Mobile, and Montgomery.

Fig. 1 shows the section of country through which the storm passed.

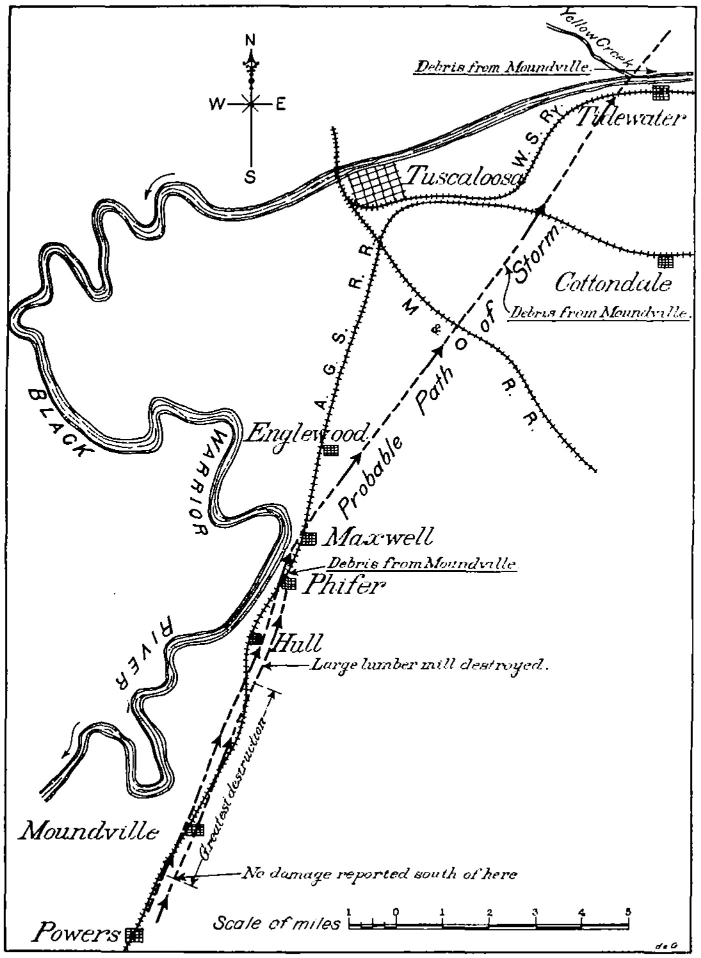

FIG. 1.—Path of tornado at Moundville, Ala., January 22, 1904.

ARRANGEMENT OF LIGHTNING RODS.[1]

By Prof. W. S. FRANKLIN, Lehigh University, South Bethlehem, Pa., dated February 10, 1904.

1. Good connection of a lightning rod to ground is a prime necessity in lightning rod construction.

2. The experimental and theoretical study of the transmission of rapid electrical oscillations and of abrupt electrical pulses along wires or rods has led to the recognition of the following facts:

(a) Straightness and directness of path to earth is the most important condition in so far as the arrangement of the rod is concerned.

(b) A given weight of metal is much more effective as a carrier of rapid electrical oscillations or abrupt electric pulses when it is in the form of a ribbon or thin-walled tube or wire cable than when it is in the form of a solid rod.

3. If the path along the rod to ground is roundabout, the more direct path through the protected (?) structure is apt to be chosen by the electrical discharge, notwithstanding its poor electrical conductivity and in spite of any ordinary degree of insulation of the rod.

4. The arrangement shown in fig. 1 affords very direct com-

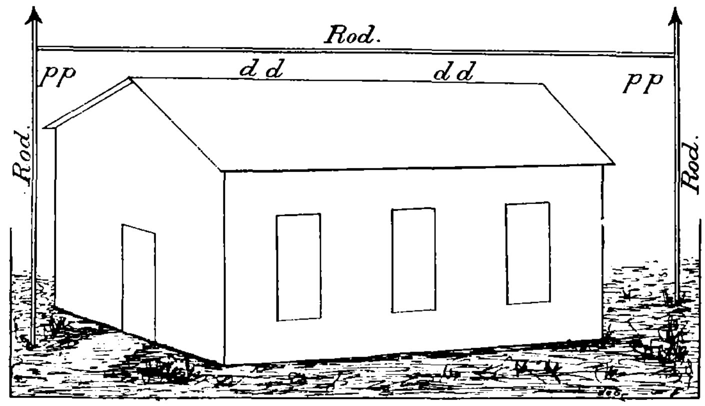

FIG. 1.—A well-protected structure.

munication to ground from the regions *pp pp*, which regions are, therefore, to be considered as well protected. On the other hand, the ground communication from the region *dd* is unnecessarily roundabout, and this region *dd* is, therefore, unnecessarily exposed to danger.

Given a good ground connection, then directness of path to ground from the region which is to be protected is so important that the matter of insulating the rod from the building, either by air spaces or by glass, is of no importance whatever in comparison. If the path is direct, there is no need of insulation; and if the path is roundabout, effective insulation is not practicably feasible.

[1] This article was written, at the request of the Editor, as an answer to a question by a correspondent of The Rural New-Yorker in regard to the arrangement of lightning rods.

A NEW NEPHOSCOPE.

By LOUIS BESSON.

[Translated from Annuaire de la Société Météorologique de France, February, 1903, p. 29.]

The vertical component of the movement of the clouds introduces into nephoscopic observations an error, the law for which I have recently studied,[1] at least as regards the direction. All along any great vertical circle, in whose plane a cloud moves, the error in direction is zero (or equal to 180°), but it is easy to see that the error in the relative velocity is at its maximum there. I have shown that by making two determinations at the same elevation, perpendicular to the movement of the clouds, the exact direction, and at the same time the inclination can easily be obtained; but this solution is only rigorous if the vertical component has the same value in the whole extent of the sky; moreover, the work of the observer is doubled.

If, neglecting the measurement of the inclination, it is proposed only to determine, under the best possible conditions, the direction and the relative velocity, it is best to observe at the zenith, because there the error in the direction is zero, and the error in the relative velocity is generally negligible. Now, it must be acknowledged that near the zenith the use of the nephoscopic herse[2] is very inconvenient on account of the fatiguing position that the observer must maintain. For such observations the dark nephoscopic room, such as is used at the observatory for dynamic meteorology at Trappes and at the municipal observatory of Montsouris[3] is certainly the most convenient arrangement, but the pictures of the clouds upon

[1] Annuaire de la Société Météorologique de France, 1902, p. 180.
[2] Annales de l'Observatoire Municipal de France, 1901, p. 50.
[3] Annales de l'Observatoire Municipal de France, 1901, p. 17.